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ABSTRACT

Because change in mathematics teachers' instructional practices is fundamental to the vision of school mathematics education embodied in the NCTM Standards documents, it is critical that mathematics teacher educators develop a thorough understanding of the process of change in teaching practice. To date, the process of change has remained somewhat intractable. In order to better understand the process, a model for conceptualizing teacher change developed during a two-year study of mathematics teachers' implementation of an innovative curriculum program. The model is based on a constructivist view of teaching and learning and evolved as the study unfolded. Contains 19 references. (Author/MKR)

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A REFLECTIVE CYCLE:
THE EVOLUTION OF A MODEL OF TEACHER CHANGE

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ABSTRACT

Because change in mathematics teachers' instructional practices is fundamental to the vision of mathematics education in schools embodied in the NCTM Standards documents, it is critical that mathematics teacher educators develop a thorough understanding of the process of change in teaching practice. To date, the process of change has remained somewhat intractable. In order to better understand the process, a model for conceptualizing teacher change developed during a two-year study of mathematics teachers' implementation of an innovative curriculum. The model is based on a constructivist view of teaching and learning and evolved as the study unfolded.

A critical problem facing mathematics education today is the translation of the vision of mathematics teaching and learning contained in the two National Council of Teachers of Mathematics (NCTM) standards documents (NCTM, 1989, 1991) into actual practice in our schools. This vision suggests learning environments that are quite different from the lecture-dominated norm that exists today (Goldsmith & Schifter, 1993; Hart, 1991; NCTM, 1991). Clearly some of what Richardson terms "significant and worthwhile changes" in mathematics teachers will be a necessary condition for the realization of that vision (NCTM, 1991; Richardson, 1990).

Often, an understanding of complex processes can be enhanced through the development of a model. Indeed, with respect to the construction of a model for teacher change, Goldsmith and Schifter (1993) note that "the means by which teachers develop their practice are as yet little understood; it is critical that we develop some models for the growth of teaching practice if we are to succeed in stimulating such change on a wide scale" (p. 124).

During a study which investigated the conditions under and the means by which worthwhile change in mathematics teachers' practices can be effected, a constructivist model of teacher change evolved. This model is useful in conceptualizing the process of change in mathematics teaching practice.

A Constructivist View of Learning

A current theoretical viewpoint that is ubiquitous in mathematics education is constructivism: the theory that learners actively construct their own knowledge through interaction with their environment. As it is with any philosophical point of view, there are differences, sometimes important ones, in the ways in which

different educators who would label themselves "constructivist" view the teaching/learning process. It is the similarities, however, which characterize this viewpoint. Noddings (1990), believes that most constructivists would agree on the following:

- All knowledge is actively constructed.
- Knowledge is organized in networks that are increasingly more complex and abstract.
- Constructed knowledge is under a nearly continuous state of reorganization and restructuring.
- The construction of knowledge occurs as a reflective activity in an attempt to make experience meaningful.

The notion that knowledge and cognitive structures are actively constructed by learners (Cobb, 1988) is a unifying theme in many contemporary theories of learning. This belief is derived directly from Piaget's stress on the learner's actions, both concrete and mental. These constructions occur when current knowledge structures lead to some form of mental conflict or dissonance (von Glasersfeld, 1983). Such mental action occurs as the result of reflection on and abstraction from interactions with one's environment (Cobb, 1988, 1989; von Glasersfeld, 1983). However Cobb (1988) cautions that "analyses that focus solely on individual children's construction of knowledge tell only half of a good story" (p. 34), the other half being a sort of institutionalized cultural effect on the individual's reflective activity.

Reflective abstraction of this sort must result in some form of restructuring of knowledge (Confrey, 1991). Moreover, one way to view such a process is in

terms of a cycle (Confrey, 1991; Underhill, 1991). Figure 1 presents a cyclic model of the construction of knowledge.

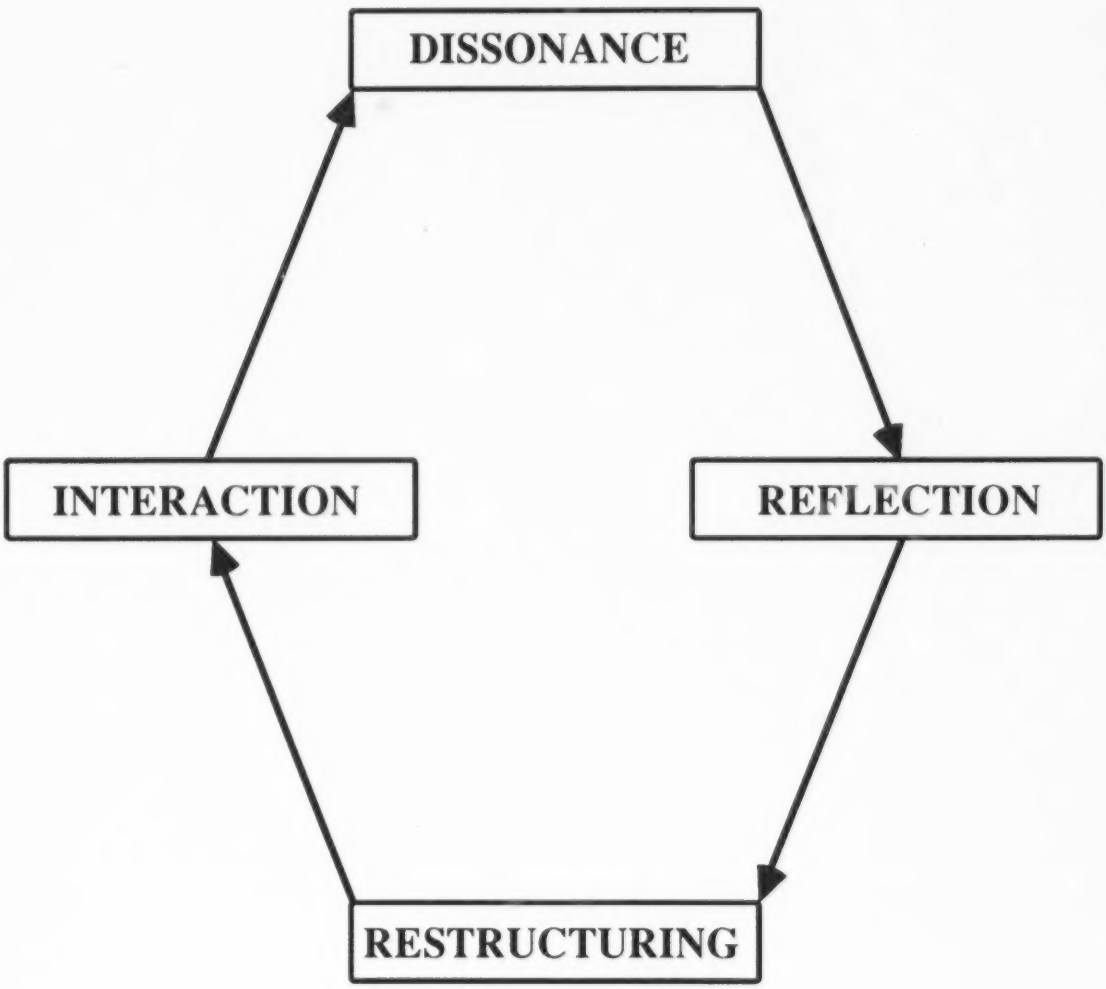

Figure 1: A Cyclic Model of the Construction of Knowledge

Constructivist Theory Applied to the Problem of Teacher Change

If teachers are viewed as reflective thinkers who use a problem-solving approach to instructional practice (Carpenter, Fennema, Peterson, Chiang & Loef, 1989; Wood, Cobb, & Yackel, 1991), then constructivist theory can be extended to provide a theoretical framework for the study of teacher change.

Hart (1991) believes that learning is a process of providing structure and organization to one's world in order to make sense of experience. Moreover, she believes that teachers, in attempting to change, will modify their knowledge and beliefs about teaching and learning if their attempts are made problematic.

Cooney (1993) acknowledges that the teaching of mathematics is, by its very nature, a problematic activity. Furthermore, he suggests a fundamental role for reflectivity in the process of teacher change. In his view, "the notion of reflection is rooted in the constructivist notion of adaptation; the relevance of reflection and adaptation ... is that neither can meaningfully take place from a closed, dualistic perspective" (p. 45).

Thus, in applying a constructivist perspective to conceptualize the problem of change in teaching practice, aspects of instructional practice that become problematic provide a form of mental dissonance, while change in practice is viewed as a form of restructuring that results from reflective activity. Figure 2 depicts this extension.

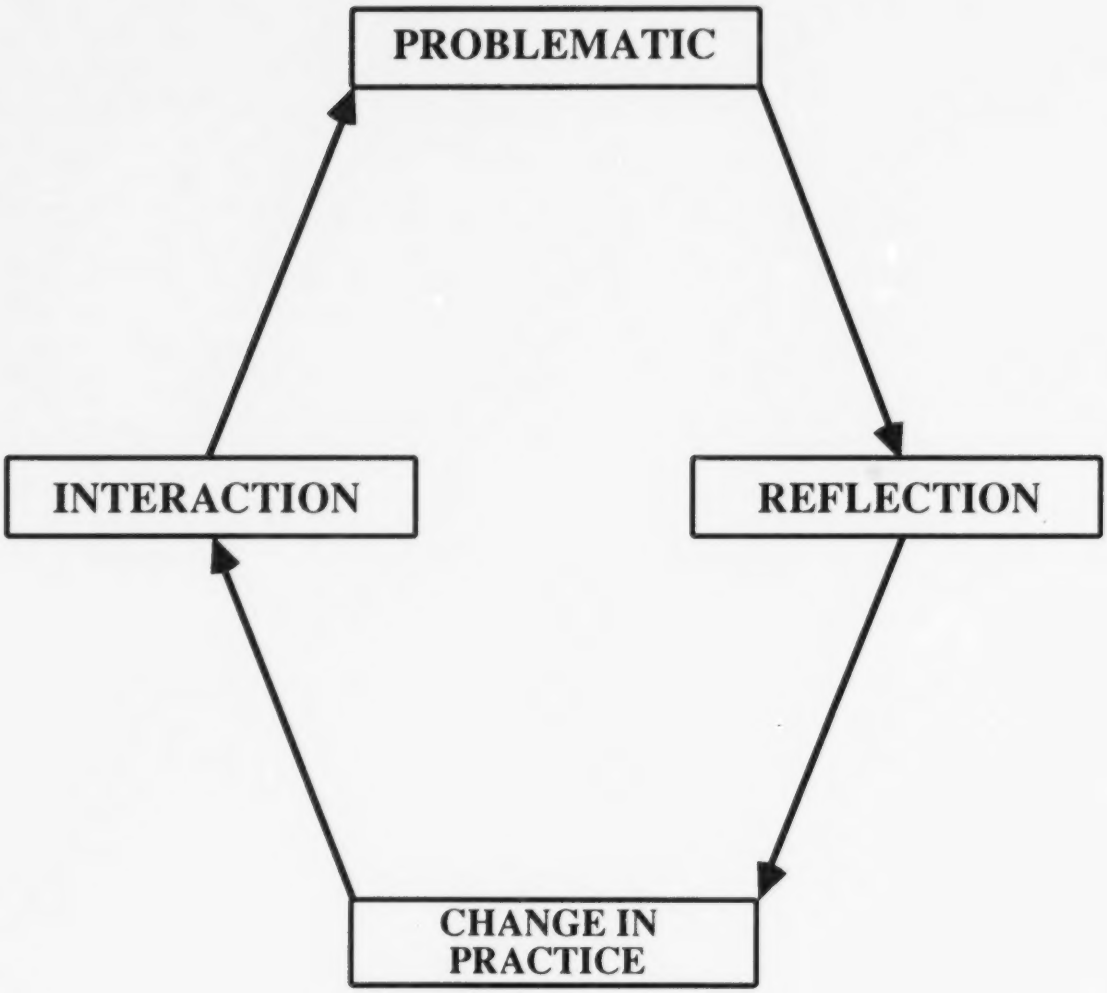

Figure 2: Applying a Constructivist Model to the Problem of Teacher Change

An Evolving View of Reflection

During the 1992-93 school year, a case study was opened of a mathematics teacher involved in a curriculum innovation project in a large eastern city. The purposes of the study were to seek evidence of change in teaching practice and to investigate the process by which any such change might occur. Subsequently, this case study was extended to the 1993-94 school year, during which two additional cases were opened.

For each of the three teachers who were studied, reflective activity was central to their practice of teaching. Perhaps the strongest evidence of such reflective practice can be seen in the case of Gina, a seventh-grade teacher in a school with a high proportion of English as a second language (ESL) students.

During the study, Gina was working on a Master's degree in Teaching English to Speakers of Other Languages (TESOL). The connection between Gina's graduate studies and professional situation are obvious, and were confirmed during interview. This alone provides evidence of some degree of teacher reflectivity, but Gina's application of her graduate work to her everyday practice provides even more powerful evidence. She describes her use of TESOL methods while teaching mathematics in these terms:

> Anything that a teacher would do in an ESL class is going to catch any other student that would normally fall through the cracks, if certain techniques or methods weren't used. The whole idea of presenting things visually, going over certain words, emphasizing terms, giving them sort of this background knowledge that you might assume native speakers have, but sometimes they just

> don't. I don't think there's one TESOL method that doesn't help other students. I think I'm a better math teacher, having had the ESL experience.

During their implementation of the curriculum innovation, these teachers reflected on their classroom interactions with students, on perceived problems with instruction, and on the changes which they consciously tried to make. Evidence of the latter is provided by another of the teachers, Diane, who said:

> I wish I had the ability to take more risks with my teaching; to go out on a limb and try something creative - really creative.

Similar empirical evidence from this study implies that the previous model of teacher change does not adequately account for the role of teachers' reflections in the process of change. As the model evolved (see Figure 3), reflective activity came to be viewed as the context within which the process of change occurs. In this iteration of the model, change is still conceptualized as a cyclic process, but reflection, rather than just one point of the cycle, is viewed as the means by which those points are joined.

Understanding Differences Across Cases

As the study of the three teachers unfolded, it became increasingly clear that the process of change in the cases of Diane and Gina was quite similar, while it differed substantively from the other case. For example, an analysis of classroom observations of the use of the innovative curriculum by Diane and Gina suggested that they both were attempting to take a less authoritative role in the classroom while simultaneously developing their students active participation in their own learning.

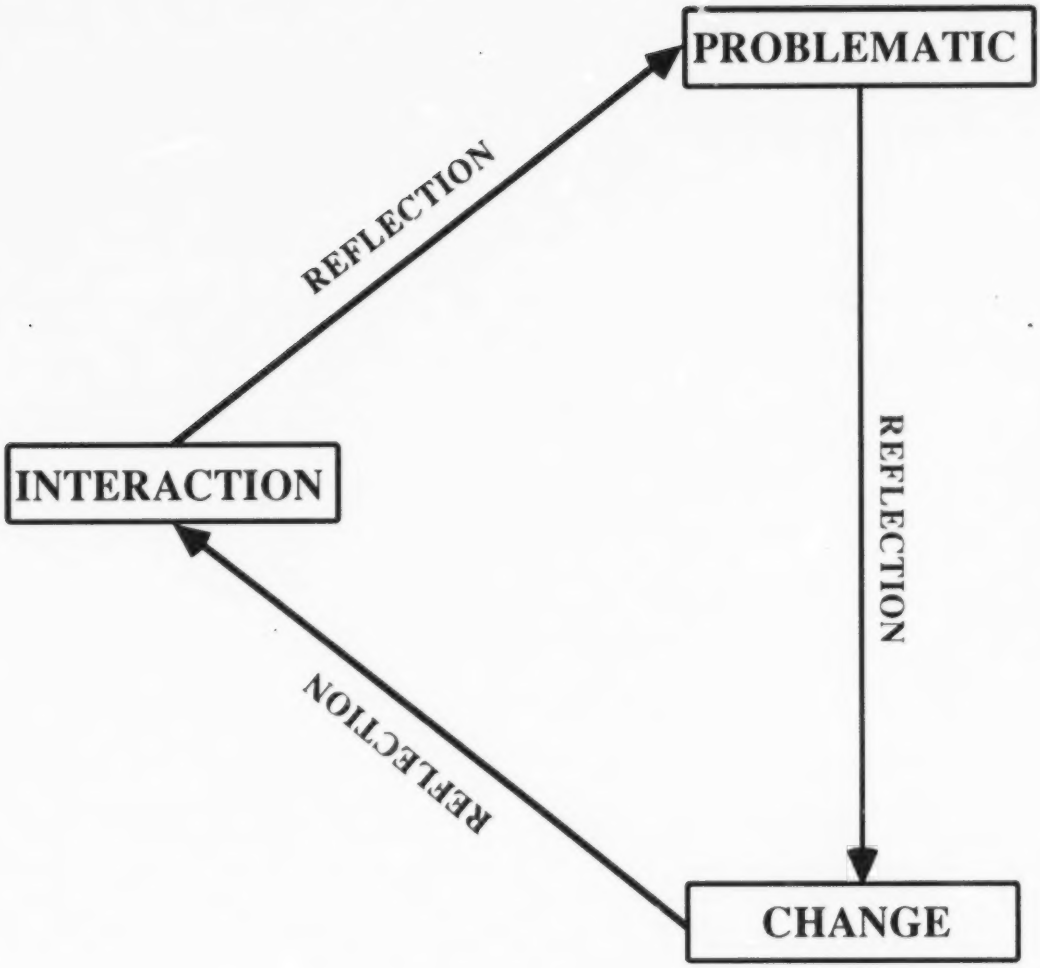

Figure 3: Reflection: The Context for a Cycle of Change

Both began providing much less information to students directly, preferring instead to draw the information from students through the use of appropriate questions. On the other hand, Kathy, the third teacher in the study, explains her reluctance to incorporate reading mathematics, one of the innovative approaches, in this way:

> When we're reading in class, I'm not explaining anything to them. It's just words to them. They want to know, "What does it mean?" And we weren't getting to that: "*These* words mean *this*!"

Thus, while Diane and Gina began to shift away from a teaching role as a "teller," it was the absence of precisely such "telling" that appears to have caused the discomfort that Kathy describes. Because the models of teacher change already presented provide no means to explain such differences in the process of change, a further alteration in the model proved necessary.

Teachers' instructional behavior in mathematics derives from their beliefs about the nature of mathematics (Thompson, 1992). Moreover, these beliefs determine the extent to which teachers are able to adopt the sorts of innovations envisioned by the current reform effort in school mathematics (Ball, 1990).

In order to account for the cross-case differences encountered in this study, information was collected about these teachers' beliefs concerning the nature of mathematics itself, as well as the learning and teaching of mathematics. Ernest (1989) discusses three possible views of mathematics that an individual might hold. He describes these as:

- a Platonist view: Mathematics is a static but unified body of knowledge consisting of interrelated structures and truths. Mathematics is discovered, not created.

- an instrumentalist view: Mathematics is a useful collection of facts, rules, and skills which can be brought to bear on a wide range of human endeavors.
- a dynamic, problem-driven view: Mathematics is a continuously expanding field of human inquiry that is not a finished product, but open to revision. Mathematics is created, not discovered .

Indeed, Diane and Gina, the two teachers who exhibited similar patterns of change, both chose the dynamic, problem-driven view as the best description of their belief about the nature of mathematics, while Kathy, who exhibited different sorts of change, chose the Platonist view. Moreover, differences in belief structures are evident in Diane's description of mathematics as "logical and invented", compared with Kathy's description of mathematics as "necessary and abstract." A comparison of Gina's description of the process of learning and teaching mathematics, which she called, "Collaborative and fun," with Kathy's description, "Difficult and frustrating," further highlights these differences.

Fullan (1982, 1991) views the alteration of beliefs as one of three dimensions of change in teaching practice. Beliefs color a teacher's interpretation of classroom interactions and help to determine which aspects of practice a teacher finds problematic, as well as the ways in which the teacher addresses the problematic. From this perspective, beliefs form a foundation for the reflective cycle of change. Figure 4 incorporates this added dimension of beliefs into the model of the process of teacher change.

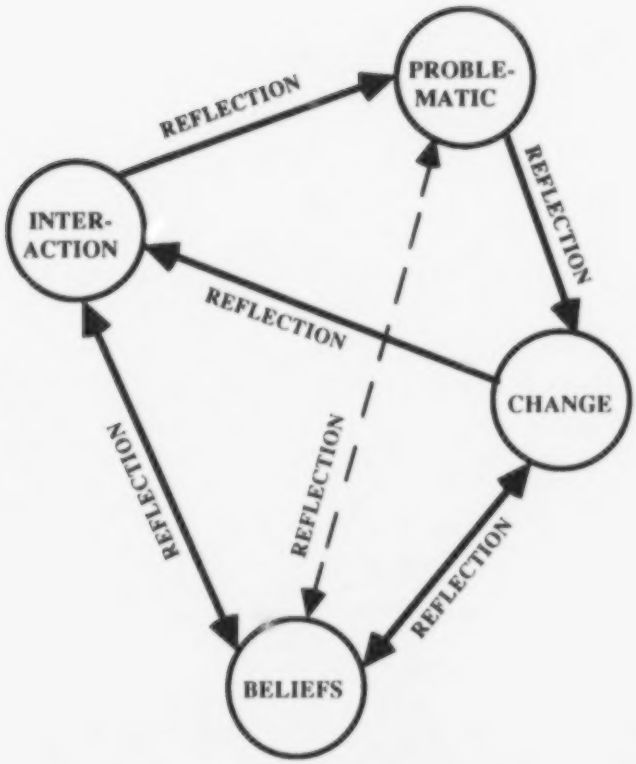

Figure 4: Teacher Beliefs as the Foundation for A Constructivist Model of Change

Reflecting on Reflection

At many times throughout this study, these teachers were observed thinking not only upon their practice and the changes that they were attempting to make, but upon their prior reflections on these issues. Near the end of the study, Diane provided evidence of this sort of reflection. She discusses the tension in her work between procedural and conceptual knowledge, a recurrent theme during interview sessions:

> I'm so much more aware of it now. It may have been there, and I didn't know what it was or didn't notice it. Now, when it's there, I know it's there; partly because of our dialogue about it.

Thus, in Figure 5, metacognition, the uniquely human ability to monitor one's own reflective activity, is placed at the heart of a model of the process of change in teaching practice.

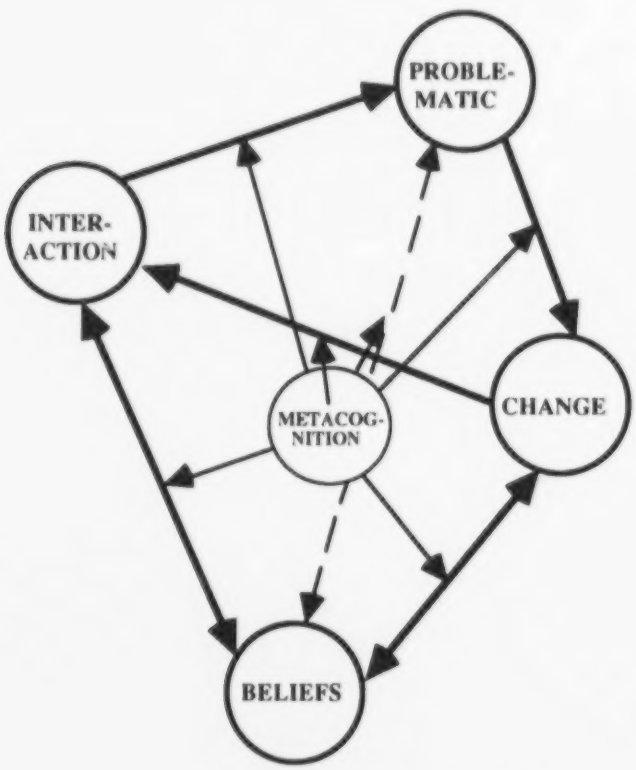

Figure 5: A Constructivist Model of Teacher Change Based on Beliefs and Monitored by Metacognition

Conclusion

The sorts of changes envisioned by the current reform effort in school mathematics education, of which the NCTM Standards are a major part, will require many practicing teachers to make fundamental changes in their instructional practices. If academe is to play a significant role in bringing about such change, a much deeper, more complete understanding of the process of change will be necessary. Such an understanding is enhanced by the synthesis of models that derive from both theoretical and empirical considerations which can be used to conceptualize the process of change .

The process of teacher change has remained intractable partly due to its complexity and partly due to the methods by which evidence must necessarily be accumulated. Shulman's (1986) arguments favoring the development of a case literature in teacher education are persuasive and ought to be extended to the problem of teacher change. Only by subjecting to public scrutiny a wealth of data amassed in a variety of classrooms concerning a great number of teachers who are struggling with the process of change can we hope to come to an understanding of this process ourselves. Without such an understanding, the current reform effort in school mathematics education is likely to go the route of previous such efforts.

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